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TRIPLE DISCHARGE PUMP WITH EPICYCLIC GEAR TRAIN: A REVIEW

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ABSTRACT

This paper gives outlines Epicyclic internal gear pump where one sun gear is meshed with three planet gears to achieve variable discharge rate as per requirement. This paper describes techniques for the design, construction, and testing of a Epicyclic internal gear pump. In many applications it is required to drive the actuators hydraulic cylinder or hydraulic motors at variable speed. This is only possible by variable discharge from a variable displacement pump (this pump has very high cost approx Rs.90000/-) so it is not possible to use it. One method employed is to use a pump of higher discharge capacity. But higher capacity means higher cost and higher power consumption. Hence there is need of special pump system at low cost so that the requirement of variable discharge is met easily without much cost and set up.

Keywords: Pump, Epicyclic Gear, Maximum Discharge, Internal Gear Pump.

I. INTRODUCTION

This system comprises of three internal gear crescent pumps mounted in parallel around epi-cyclic gear train i.e. the sun gear of the drive train drives the planet gears mounted on the input shaft of each gear pump. The input to all three gear pumps come from a common tank where as the output from the gear pumps is delivered to a common manifold thus it is possible to get maximum discharge when needed.

The minimum output available is that of one pump. Maximum output available is that of three pumps.This is possible as each of pumps is capable of being de-coupled from circuit.

II. INTERNAL GEAR PUMP

The internal gear pump is a rotary flow positive displacement pump design, which is well-suited for a wide range of applications due to its relatively low speed and inlet pressure requirements. These designs have only two moving parts and hence have proven reliable, simple to operate, and easy to maintain. They are often a more efficient alternative than a centrifugal pump, especially as viscosity increases. Internal gear pumps have one gear with internally cut gear teeth that mesh with the other gear that has externally cut gear teeth. Pumps of this type are made with or without a crescent-shaped partition. Either gear is capable of driving the other, or the design can be operated in either direction. Designs are available to provide the same direction of flow regardless of the direction of shaft rotation. As the gears come out of mesh on the inlet side, liquid is drawn into the pump. The gears have a fairly long time to come out of mesh allowing for favourable filling. The mechanical contacts between the gears form a part of the moving fluid seal between the inlet and outlet ports. The liquid is forced out the discharge port by the meshing of the gears.

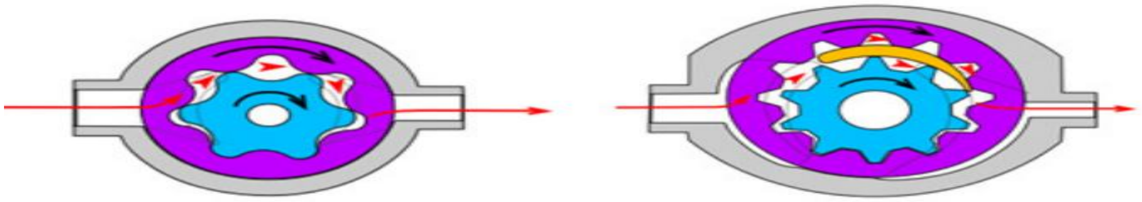


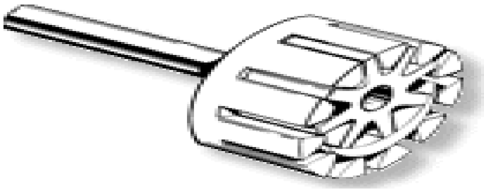
Fig.1.Internal Gear Pumps with and Without A Crescent-Shaped Partition Resp.

Internal gear pumps are commercially available in product families with flows from 1 to 340 m3/h (5 to 1500 gpm) and discharge pressures to 16 bar (230 psi) for applications covering a viscosity range of 2 to 400,000 cSt (40 to 2,000,000 SSU). Internal gear pumps are made to close tolerances and typically contain at least one bushing in the fluid. They can be damaged when pumping large solids. They can handle small suspended solids in abrasive applications but will gradually wear and lose performance. Materials of construction are dictated by the application and include cast iron, ductile iron, bronze, cast steel, and stainless steel. Small internal gear pumps frequently operate at four-pole motor speeds (1800 rpm) and have operated at two-pole speeds (3600 rpm). As the pump capacity per revolution increases, speeds are reduced. Larger internal gear pumps typically operate below 500 rpm. Operating speeds and flow rates are reduced as the fluid viscosity increases. Pinion-drive internal gear pumps are a distinctive subclass with unique operating characteristics. They are typically direct-drive arrangements operating at two-, four-, and six-pole speeds for flows below 750 L/min (200 gpm) on clear to very light abrasion, low-viscosity, hydrocarbon-based fluids. They are available in single or multistage module designs capable of pressures to 265 bar (4000 psi).

Internal Gear Pump Overview

Internal gear pumps are exceptionally versatile. While they are often used on thin liquids such as solvents and fuel oil, they excel at efficiently pumping thick liquids such as asphalt, chocolate, and adhesives. The useful viscosity range of an internal gear pump is from 1cPs to over 1,000,000cP.

In addition to their wide viscosity range, the pump has a wide temperature range as well, handling liquids up to 750F / 400C. This is due to the single point of end clearance (the distance between the ends of the rotor gear teeth and the head of the pump). This clearance is adjustable to accommodate high temperature, maximize



Efficiency for handling high viscosity liquids, and to accommodate for wear.The internal gear pump is non-pulsing, self-priming, and can run dry for short periods. They're also bi-rotational, meaning that the same pump can be used to load and unload vessels. Because internal gear pumps have only two moving parts, they are reliable, simple to operate, and easy to maintain.

III. WORKING

It is rotary flow positive displacement pump. It is more advantageous due to low speed and inlet pressure requirement. It consist of one external gear and one internal gear that meshes with each other and with or without crescent shaped partition.When the gears disengage on the inlet side liquid comes into the pump and forces out discharge port by the meshing of the gears.

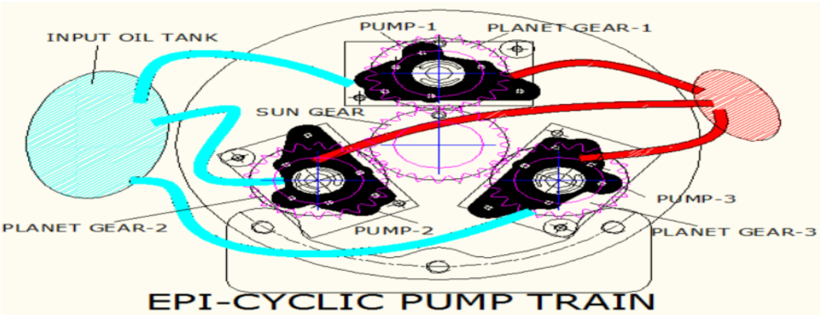


Fig.2.Detail Information of Each Component of the Pump

3.1 Liquid enters the suction port between the rotor (large exterior gear) and idler (small interior gear) teeth. The arrows indicate the direction of the pump and liquid.

3.2 Liquid travels through the pump between the teeth of the "gear-within-a-gear" principle.The crescent shape divides the liquid and acts as a seal between the suction and discharge ports.

Fig.3.Working of Internal Gear Pump

3.3 The pump head is now nearly flooded, just prior to forcing the liquid out of the discharge port.Intermeshing gears of the idler and rotor form locked pockets for the liquid which assures volume control.

3.4 Rotor and idler teeth mesh completely to form a seal equidistant from the discharge and suction ports. This seal forces the liquid out of the discharge port.

IV. LITERATURE REVIEW

E.A.P. Egbe (Mechanical Engineering Department, Federal University of Technology Minna, Nigeria) states in his Design Analysis and Testing of a Gear Pump that Nigeria depends heavily on importation of goods and machines. A shift from this trend requires the development of locally available technology. The design analysis of a gear pump that aimed at delivering 4.0913x10-4m3/s (24.55litres/min) of oil was carried out in this work. Available technology was utilized in the design and fabrication of the external gear pump. The design considered relevant theories and principles which affect the performance of a pump. The parts of the pump were produced locally from available materials. The performance of the pump was characterized and the test results showed a volumetric efficiency of 81.47 per cent at a maximum delivery of 20litres/minute. The discharge dropped with increase in pressure head at a rate of - 0.344Litres/m.

Peng Dong1 , Yanfang Liu2 , Yang Liu2 and Xiangyang Xu2 gives in his paper a method of applying two-pump system in automatic transmissions for energy conservation In order to improve the hydraulic efficiency, modern automatic transmissions tend to apply electric oil pump in their hydraulic system. The electric oil pump can support the mechanical oil pump for cooling, lubrication, and maintaining the line pressure at low engine speeds. In addition, the start–stop function can be realized by means of the electric oil pump; thus, the fuel consumption can be further reduced. This article proposes a method of applying two-pump system (one electrioil pump and one mechanical oil pump) in automatic transmissions based on the forward driving simulation. A mathematical model for calculating the transmission power loss is developed. The power loss transfers to heat which requires oil flow for cooling and lubrication. A leakage model is developed to calculate the leakage of the hydraulic system. In order to satisfy the flow requirement, a flow-based control strategy for the electric oil pump is developed. Simulation results of different driving cycles show that there is a best combination of the size of electric oil pump and the size of mechanical oil pump with respect to the optimal energy conservation. Besides, the two-pump system can also satisfy the requirement of the start–stop function. This research is extremely valuable for the forward design of a two pump system in automatic transmissions with respect to energy conservation and start–stop function.

Syed Ibrahim states in his design of compound gear trains one of the most critical components in the mechanical power transmission system in which failure of one gear will affect the whole transmission system, thus it is very necessary to determine the causes of failure in an attempt to reduce them. The different modes of failure of gears and their possible remedies to avoid the failure are mentioned in J.R. Davis (2005) ,Khurmi & Gupta (2006)], P. Kannaiah (2006) as bending failure (load failure), Pitting (contact stresses), scoring and abrasive wear, in any case it is related to the loads acting on the gear and this research deals with the Optimization of the gear design leading to the reduction in the load failure of the gears. Further, table.1 explains the different areas of research carried out by different authors on Epicyclic gear trains. This study carried out in this research shows the optimization analysis of the epicyclic gear train in India to reduce load failure. The analysis is restricted to the optimization of gear train through load analysis of the gears, pinions and annulus including the sun and plant gears, and finding out the optimal load conditions for the gear train to perform effectively without leading to load failure. Epicyclic Gear Trains have been used in Industry for their many advantages which includes high torque capacity, comparatively smaller size, lower weight, improved efficiency and highly compact package, however there has not been a comprehensive study of its load bearing performance with respect to different parameters such as module, material, and power of the epicyclic gear trains. This research paper provides an attempt in filling that gap in aiming to get the epicyclic gear trains load performance on different parameters. This process helps in finding the optimized design for the epicyclic gear trains in which it has the best performance without any failure and with minimum Loads acting on the gears. The main aim of this research investigation is to optimize the epicyclic gear train through load analysis, to prevent load failure from happening in the future epicyclic gear train dynamics including mesh efficiency.

Dr. Eng. Enrico Galvagno Dipartimento di Meccanica Politecnico di Torino presents in his paper an epicyclic gear train dynamic mathematical model including mesh efficiency, bearings/seals losses and inertial effects. The mathematical model treats separately the mesh between sun and planets gears and the mesh between planets and ring gears. Two different ordinary efficiency values for each gear pair can be specified for forward and reverse power transmission through it. The mesh efficiency is inserted into the dynamic model through a change in the direction of the mean reaction force between tooth surfaces. The extension of the equations valid for ordinary gearing to elementary gear train with epicyclic arrangement is made by using the kinematic inversion .A formula for selecting the correct efficiency value, to be used in the model, depending on the direction of power flows along the epicyclic gear train is presented. Finally, in order to check the validity of the dynamic model proposed, a steady-state working condition is analysed in detail and the mesh efficiency resulting from a numerical simulation of the model is compared with analytical formulas .

V. CONCLUSION

From the above review literature,we come to know that it has low discharge and time and electricity required is high.The above problem can be solved by using triple epicyclic gear train. By using planetary gear train and sun gear we can increase discharge also we can save electricity and time.Electricity can be reduced by using only one electric motor for running all the three simultaneously or individual pump and we get variable flow of liquid. which can be use to variable discharge of fluid.Due to compactness of the design of triple discharge pump the cost of the pump can be reduced.

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